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SEISMIC ANALYSIS OF MULTI STORIED BUILDINGS WITH FLOATING COLUMNS

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Abstract : Earthquakes in different parts of the world demonstrated the hazardous consequences and vulnerability of inadequate structures. In present scenario buildings with floating column is a typical feature in the modern multistory construction in urban India. The floating column is a vertical element which at its lower level rests on a beam. The seismic inertia forces generated at its floor levels in a building need to be brought down along the height to the ground and any deviation or discontinuity in this load transfer path results in poor performance. Thus features such as floating columns are highly undesirable in buildings built in seismically active area. Present study examines the adverse effect of the floating columns in building. Models of the frame are developed for multi-storey RC buildings with and without floating columns to carry out comparative study of structural parameters such as natural period, base shear, and horizontal displacement under seismic excitation. Results obtained depicts that the alternative measure of providing lateral bracing to decrease the lateral deformation, should be taken. The RC building with floating column after providing lateral bracing is analyzed. A comparative study of the results obtained is carried out for all above three models. The building with floating columns after providing bracings showed improved seismic performance.

Key Words: ETABS, Floating column building, story, drift, displacement.

1 INTRODUCTION

Many urban multistory buildings in India today have open first storey as an unavoidable future. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground.

1.2 Purpose

1. Study of a High Rise Storey Building with and without floating column.
2. Designing a building with floating column along with E-TABS (18) software.
3. To evaluate the benefits of providing with floating column.
4. To evaluate the benefits of providing floating column.
5. To put side by side the results of all the models as observation simple in software.

2 Earthquake Related Terminology

- **Earthquake:** An earthquake is a spasm of ground shaking caused by a sudden release of energy in the earth's lithosphere (i.e. the crust plus of the upper mantle). This energy arises mainly from stresses built up during tectonic processes, which consist of interaction between the crust and interior of the earth. In some parts of the world earthquakes are associated with volcanic activity.
- **Focus:** It is also termed as hypocenter. The point on the fault where the slip starts is focus. The depth of focus from the ground is called focal depth.
- **Epicenter:** The point on the earth's surface vertically above the point in the crust here seismic rupture begins.

- **Epicenter distance:** The distance of the epicenter from the place of observation and recording.
- **Intensity of earthquake:** Intensity is a qualitative measure of the actual manifestation of earthquake shaking at a location during an earthquake. The intensity at a place is evaluated considering three features of shaking – perception by people, performance of buildings, and changes to natural surroundings. It is denoted in a roman capital numeral.
- **Magnitude of earthquake:** Magnitude is quantitative measure of total size of earthquake. It is a number. It is defined as logarithm to the base 10 of the maximum trace amplitude expressed in microns. An increase in magnitude by 1.0 implies about 10 time's higher waveform amplitude and about 31 times higher energy released. It is measured in Richter's magnitude.
- **Modal mass:** It is that mass of the structure which is effective in one particular natural mode of vibration.
- **Seismic weight:** It is the total weight of the building plus that part of the service load, which may reasonably be expected to be attached to the building at the time of earthquake shaking. It includes permanent and movable partitions, permanent equipment and apart of the live load.
- **Seismic mass:** It is seismic weight divided by acceleration due to gravity. Centre of stiffness: The point through which the resultant of the restoring forces of a system acts.
- **Centre of stiffness:** The point through which the resultant of the restoring forces of a system acts. Static eccentricity: It is the calculated distance between the centre of mass and the centre of stiffness.

2.1 Floating Column

The floating column is a vertical member which rest on a beam and doesn't have a foundation. The floating column act as a point load on the beam and this beam transfers the load to the columns below it. But such column cannot be implemented easily to construct practically since the true columns below the termination level are not constructed with care and hence finally cause to failure.

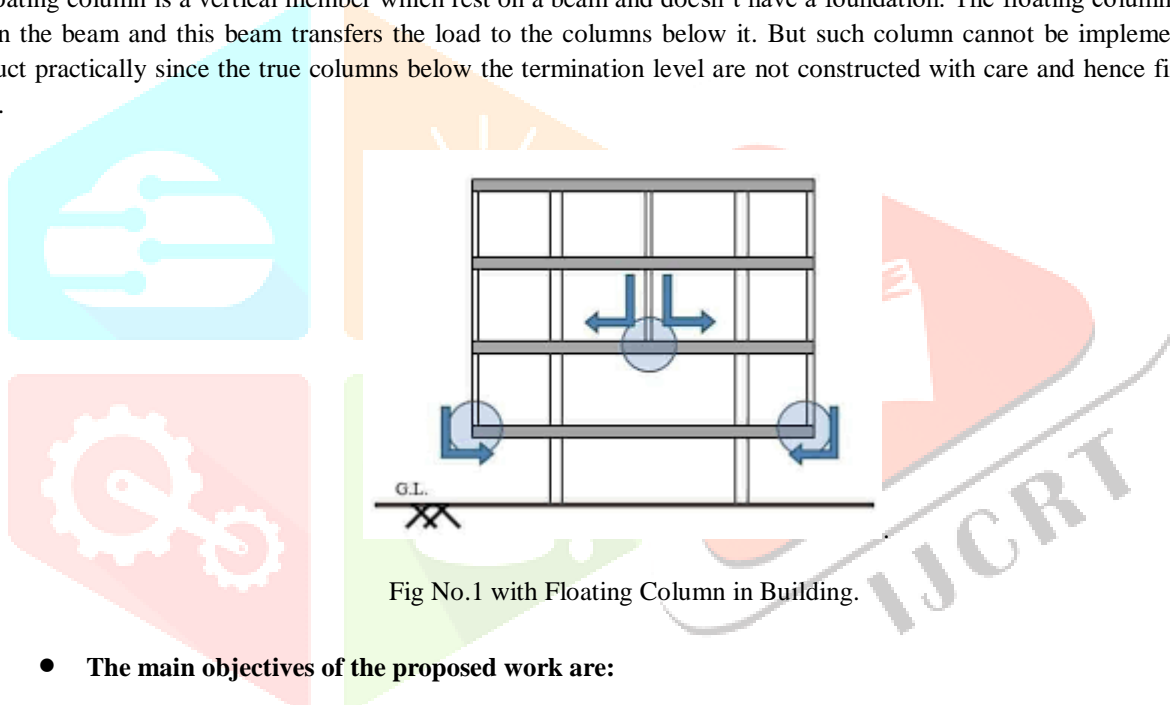


Fig No.1 with Floating Column in Building.

- **The main objectives of the proposed work are:**

1. To compare the modal response of with and without floating column.
2. To compare the Base shear, Storey drift, Storey displacement and maximum displacement of each storey.
3. To observe the of the structure for Time history analysis.

2.2 Advantages of Floating Columns

1. A floating column is primarily used to meet the architectural requirements of a building. Floating columns are noticeable when there is a large span hall with rooms on the upper floor like a hotel or auditorium on the lower floor.
2. Floating columns are useful in the construction of soft floors.
3. The project layout at each site may be different.
4. The rooms can be divided and some area can be raised without raising the whole area.

3 METHODOLOGY AND STRUCTURAL PLANNING

3.1 OBJECTIVES

Comparison between these points.

- Story Displacement
- Story Drift
- Story Stiffness
- Member Forces
- **Structural planning**

A G+5, G+7 storied building with floating column and without floating column located in zone III of India as per code IS 1893(Part1):2016 were taken for the investigation.

In this study, first a normal building without floating column is modeled as model 1.

In model 2 floating columns located at ground floor.

In model 3 without floating column building.

In model 4 with floating column building.

3.2 Project statement:

3.2.1 Salient features:

Type of the building: Residential

Type of construction: R.C.C Framed Structure.

Feature: Floating column building.

3.2.2 Material Properties for Regular and Irregular Configuration.

1. No of Stories: 8 (G + 7)
2. Beam size: 0.35mx0.30 m
3. Column size: 0.45mx0.35 m
4. Slab size: 0.125 m
5. Concrete grade : M25
6. Live load: 2.5 KN/m²
7. Dead load: 1.5 KN/m²
8. Density of concrete: 25 KN/m³
9. Seismic Zones: Zone 3
10. Steel grade : Fe500
11. Importance factor: 1.5
12. Plinth height or Foundation depth: 1.5
13. Ground floor height: 1.5
14. Typical story height : 3
15. Structure class: C
16. Concrete Design Code: IS 456: 2000
17. Earth quake design code: IS 1893: 2016
18. Seismic Zone factor (Z): 0.16

Natural periods and average response acceleration coefficients:

For five – Storied building with Setback:

Fundamental Natural period, $T_a = 0.075 * h^{0.75}$

(For Bay Frame) = $0.075 * 150.75$

3.3 Types of loads

Various types of loads on structures and requiring in consideration in design are

- **Dead load**
Dead loads are due to self weight of the structure. Dead loads are the permanent loads which are always present. Dead loads depend upon the unit weight of the material. Dead loads include the self weight of walls, floors beams, columns etc. and also the permanent fixtures present in the structure.
- **Live load**
Live loads on floors and roofs consists of all the loads which are temporarily placed on the structure, For example, loads of people, furniture, machines etc. Live loads keep on changing from time to time. Live loads are also

called as imposed loads. Various types of imposed loads coming on the structure are given in IS 875 (Part-2): 1987. The imposed loads depend upon the use of building.

- **Earthquake load**

Earthquake loads depend upon the place where the building is located. As per IS 1893-2016 (General Provisions for Buildings), India is divided into four seismic zones. The code gives recommendations for earthquake resistant design of structures. Now, it is mandatory to follow these recommendations for design of structures.

3.4 List of IS code used in analysis and design

- IS 456-2000 Plain and Reinforced concrete
- IS 875-1987 Part-I for Dead Load
- IS 875-1987 Part-II for Live Load
- IS 1893 – 2016 for Earthquake Load

3.5 Load combination

A load combination results when more than one load type acts on the structure. Building codes usually specify a variety of load combinations together with load factors(weightings) for each load type in order to ensure the safety of the structure under different maximum expected loading scenarios.

Load combinations used in the design are

- 1.5 DL
- 1.5DL + 1.5LL
- 1.2DL + 1.2LL + 1.2EO
- 1.2DL + 1.2LL - 1.2EO
- 1.5DL + 1.5EQ
- 1.5DL - 1.5EQ
- 0.9DL + 1.5EQ
- 0.9DL - 1.5EO
- 1.2DL + 1.2LL + 1.2EQ
- 1.2DL + 1.2LL + 1.2EQ
- 1.5DL + 1.5EQX
- 1.5DL + 1.5EQY
- 0.9DL + 1.5EQX
- 0.9DL + 1.5EQY

3.6 METHOD OF SEISMIC ANALYSIS

Seismic analysis is a subset of structural analysis and the calculation how to behavior of structure to earthquake .It is a part of the process of structural design ,earthquake engineering or structural assessment in region where earthquake is are prevalent. A building has the potential to ‘wave back and forth during an earthquake or even a severe wind storm. This is ‘fundamental mode’ and is the lowest frequency of building response most building, however higher modes of response, which are uniquely activated during earthquake.

3.6.1 Time History Method

A linear time history analysis overcomes all the disadvantages of modal response spectrum analysis, provided non-linear behavior is not involved. This method requires greater computational efforts for calculating the response at discrete time. One interesting advantage of such procedure is that the relative signs of response qualities are preserved in the response histories. This is important when interaction effects are considered in design among stress resultants.

4 PARAMETRIC INVESTIGATION

4.1 OBJECTIVES

Comparison between these points.

- Story Displacement
- Story Drift
- Story Stiffness
- Member Forces

4.2 MODELS

4.2.1 G + 5 WITHOUT FLOATING COLUMN

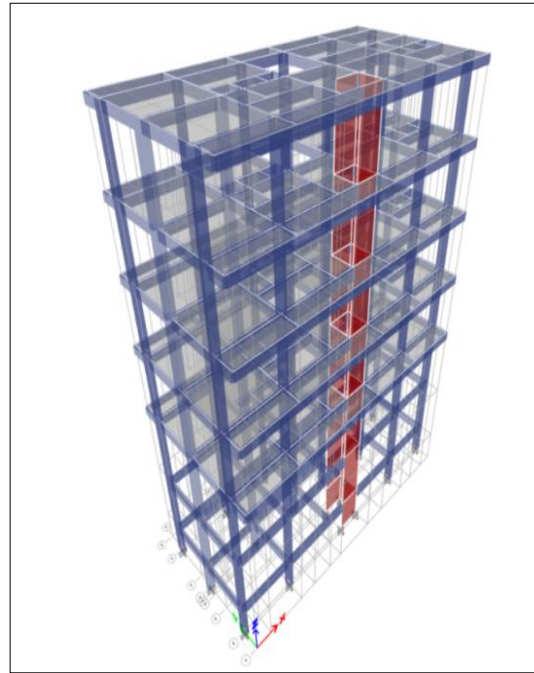
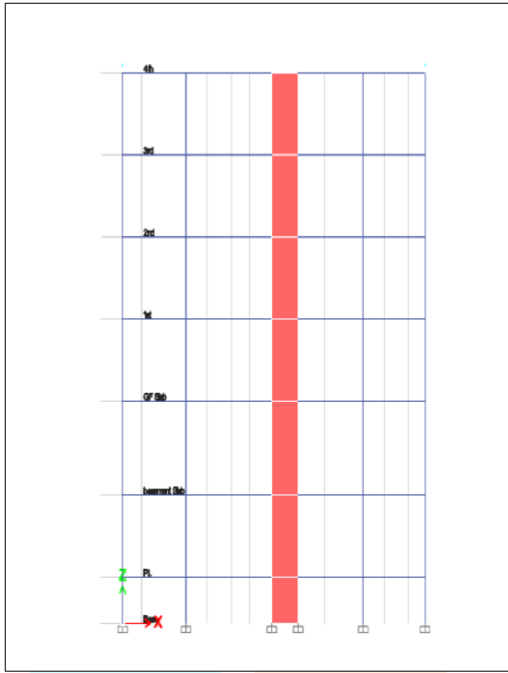


Fig no 2 without floating column elevation
View along Grid line B

Fig no 3 without floating column
View along Grid line B

4.2.2 G + 5 WITH FLOATING COLUMN

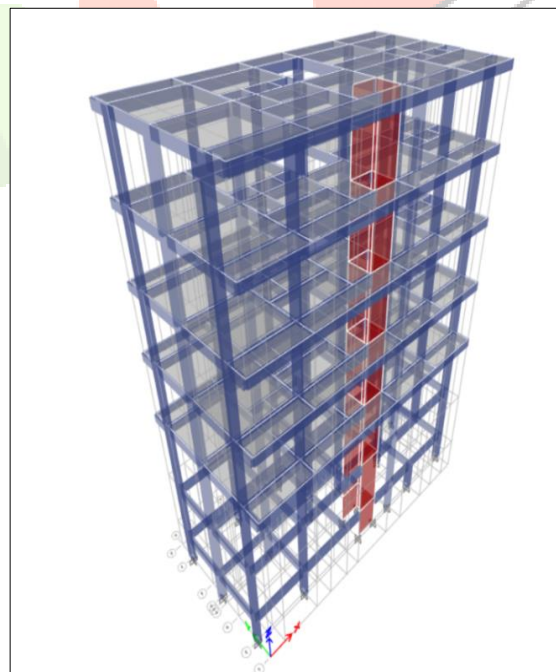
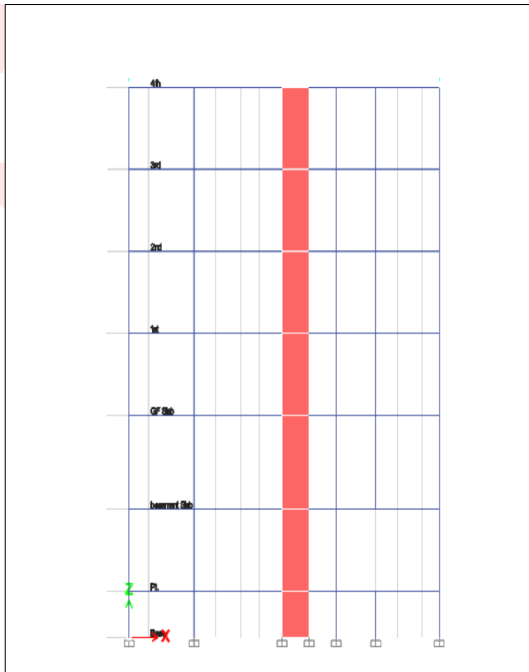


Fig no 4 without floating column elevation
View along Grid line B

Fig no 5 Without floating column 3D
View along Grid line B

4.2.3 G + 7 WITHOUT FLOATING COLUMN

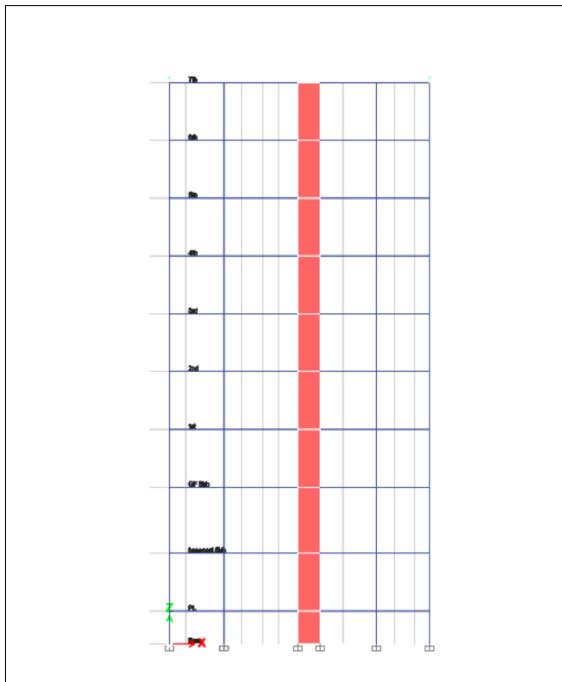


Fig no 6 Without floating column elevation
View along Grid line B

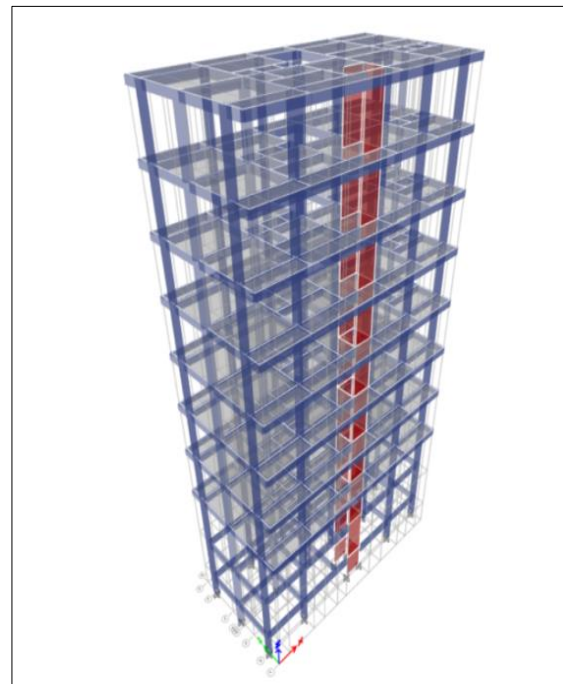


Fig no 7 Without floating column 3D
View along Grid line B

4.2.4 G + 7 WITH FLOATING COLUMN

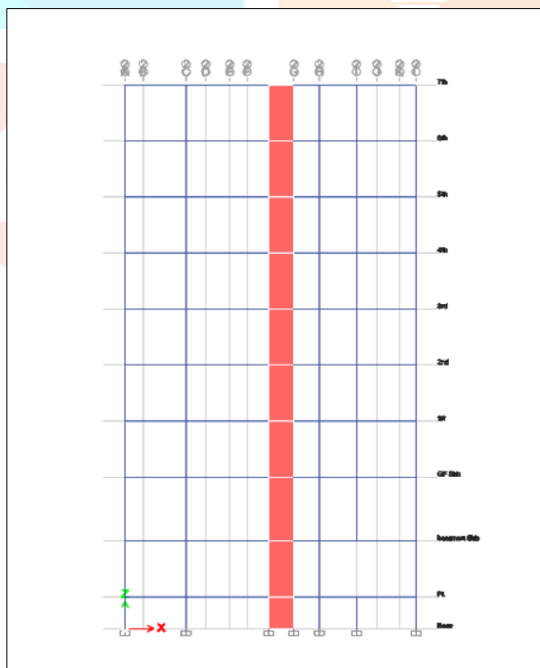


Fig no 8 Without floating column elevation
View along Grid line B

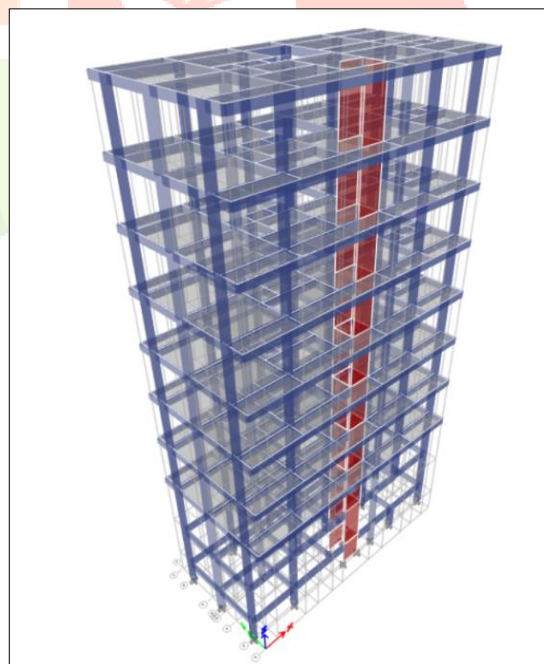


Fig no 9 Without floating column 3D
View along Grid line B

5. CONCLUSION AND REFERENCES

5.1 Storey Drift

1. According to IS:1893:2016, maximum limit for storey drift with partial load factor 1.0 is 0.004 times of storey height. Here, for 3.2m height and load factor of 1.5, though maximum drift will be 21.6mm.
2. It is observed from analysis results that for all the cases considered drift values follow around similar path along storey height with maximum value lying somewhere near about the middle storey.
3. In all the models drift values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. The storey drift is more for floating column buildings because as the columns are removed the mass gets increased and hence drift also increases.

5.2 Lateral Displacement

1. According to IS:456:2000, maximum limit for lateral displacement is $H/500$, where H is building height. For 5 storeys building model it is 57.6mm, for 8 storey building model it is 86.4mm.
2. It is observed from that for all the models considered displacement values follow around similar gradually increasing straight path along storey height.
3. In all the models displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. The displacement is more for floating column buildings because as the columns are removed the mass gets increased and hence displacement also increases.
5. By providing shear wall displacement values reduces as compared to without shear wall models for all the zones.

5.3 OBSERVATION TABLE

Table 5.3.1 : Displacement of models

Storey	With Floating column	Without Floating column	Difference In Displacement (%)
G + 5 In X Direction	10.828	10.105	6.6
G + 5 In Y direction	9.185	9.916	7.37
G + 7 In X Direction	8.153	7.451	8.6
G + 7 In Y Direction	7.036	7.029	9.9

Table 5.3.2 : Drift of models

Storey	With Floating column	Without Floating column	Difference of both column (%)
G + 5 In X Direction	0.000336	0.000313	6.63
G + 5 In Y direction	0.000214	0.000224	4.6
G + 7 In X Direction	0.000452	0.000421	0.6
G + 7 In Y Direction	0.000374	0.000379	1.3

Table 5.3.3 : STIFNESS of models

Storey	With Floating column	Without Floating column	Difference of both column (%)
G + 5 In X Direction	42277.783	38645.93	9.30
G + 5 In Y direction	790802.4	96117.54	8.87
G + 7 In X Direction	128448.184	590478.052	7.8
G + 7 In Y Direction	797462.784	769465.662	4.5

CONCLUSION

The Following conclusions are made from the Floating column study.

1. The behavior of multi storey building with and without floating column is studied under different earthquake excitation. The static analysis is done and it is concluded that by the maximum displacement and storey drift values are increasing for floating columns.
2. By checking the drift ratios, we can clearly state by increasing the height of the building the deflections and story drifts are drastically changed.
3. The axial forces are increasing in the columns other than floating columns due to transfer of loads of the floating columns to the conventional columns.
4. It is observed that bending moment in columns are greater in the top stories and lesser in the bottom stories. Bending moment varies in each model for every corner column, internal column and peripheral column.

Future scope

Will be able to understand and bring in the changes in the structures and buildings with respect to the needs. Get involved with the new techniques and perfect methods to implement the design. Easily analyze and learn the techniques to develop and construct the new design of buildings and structures. It Will increases your career opportunities as will help you to gain the upgrade in your profile Get good opportunities and an amazing job providing a good salary and career incentives.

This extensive 3D analysis of the building system provides a great opportunity to the aspirants who are looking to upgrade their careers. Those who want outlearn must have completed their studies with subjects related to construction, elevation, and mathematics. Skills related to understanding the calculations and communication can help you to improve techniques and skills.

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